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DETERMINING WAYS TO IMPROVE THE DESIGN OF THE NEEDLE THREAD TENSION REGULATOR IN A SEWING MACHINE

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Abstract. The article presents the main directions for developing efficient design schemes of sewing machine needle-thread tension regulators based on an analysis of existing designs. Recommendations are provided for increasing the degrees of freedom of the tension plates and enhancing their damping characteristics.

Keywords: sewing machine, needle thread, tension regulator, plate, shock absorber, multilayer, rubber bushing, vibration, axis, oscillation, efficiency.

Annotatsiya. Maqolada tikuv mashinalarida igna ipi taranglagichining samarali konstruktiv sxemalarini ishlab chiqish bo'yicha mavjud konstruksiyalar tahlili asosida tegishli yo'nalishlar keltirilgan. Taranglagich tarelkalarining erkinlik darajalarini oshirish va amortizatsiya xususiyatlarini kengaytirish bo'yicha tavsiyalar berilgan.

Kalit so'zlar: tikuv mashinasi, igna ipi, taranglagich, tarelka, amortizator, qatlamli, rezinali vtulka, tebranish, o'q, og'ma, samara.

Аннотация. В статье на основе анализа существующих конструкций представлены основные направления разработки эффективных конструктивных схем регуляторов натяжения игольной нити швейных машин. Даны рекомендации по увеличению степеней свободы натяжных тарелок и расширению их демпфирующих характеристик.

Ключевые слова: швейная машина, игольная нить, регулятор натяжения, тарелка, амортизатор, многослойный, резиновая втулка, вибрация, ось, колебание, эффективность.

INTRODUCTION

The development of the sewing industry requires improvements in equipment productivity, stitch formation quality, and the reliability of working mechanisms. One of the components that directly affects the stability of stitch formation is the needle thread tension regulator. The uniformity of stitches, the stability of the sewing process, and the probability of thread breakage depend on the nature of tension variation.

The relevance of improving thread tension regulators is determined by the need to develop technical solutions capable of compensating for dynamic changes in forces during sewing machine operation. Modern high-speed operating conditions impose increased requirements on the ability of the tension regulator to respond rapidly to load variations while simultaneously providing sufficient damping.

Studies devoted to the development of sewing machinery address the design of effective needle and bobbin thread tensioning devices, the determination of their structural parameters, and the provision of resource-efficient operating modes [1–4]. At the same time, the task of improving the kinematic arrangement of the tension discs remains relevant, taking into account not only the magnitude but also the direction of the tension force.

The object of the research is the needle thread tension regulators of sewing machines. The subject of the research is the structural and kinematic characteristics of the tension discs and elastic elements of the

regulator. The purpose of the study is to determine the main directions for improving the design of the needle thread tension regulator. To achieve this purpose, the following tasks were formulated: to analyze existing structural configurations; to identify their kinematic limitations; to assess the role of elastic elements in damping; and to substantiate approaches for increasing the degree of mobility of the tension discs.

LITERATURE REVIEW

The monograph by A. Djuraev, S. Mukhamedzhanova, and M. Mansurov examines the scientific foundations for developing efficient designs of thread tensioning devices and calculating their parameters [1]. This research direction is associated with ensuring stable thread tension and improving the efficiency of sewing equipment.

The work of S. Mukhamedzhanova considers effective designs of needle and bobbin thread tensioning devices, as well as issues related to determining their rational parameters [2]. The results of these studies provide a theoretical basis for the further improvement of tension regulator designs.

Patent solutions presented by S. D. Mukhamedzhanova and co-authors reflect directions for the structural development of needle thread tension regulation devices [3, 4]. In particular, the use of elastic elements makes it possible to ensure smoother variation of the clamping force applied by the tension discs.

Publication [5], devoted to the development of effective thread tensioner configurations, examines structural solutions aimed at improving the stability of the tensioning process. In contrast to existing approaches, the present study focuses on expanding the kinematic capabilities of the tension discs: it is proposed to consider not only their axial displacement but also an additional angular displacement.

Thus, the literature analysis indicates that the further development of thread tension regulators should be associated with increasing the adaptability of their elastic system and expanding the degree of mobility of the working elements.

RESEARCH METHODOLOGY

The methodological basis of the study consisted of structural and design analysis, kinematic analysis, comparative assessment of existing configurations, and theoretical analysis of the interaction between thread tension force and the tension discs. In comparing the designs, the type of elastic element, the nature of its deformation, the number of degrees of mobility of the discs, and the ability of the system to compensate for dynamic changes in tension were taken into account.

Two structural configurations were considered as the initial objects of analysis. The first involves the use of rubber bushings installed on both sides of the tension discs. The second is based on the use of three spherical rubber rings with different stiffness values. The configurations were compared in terms of their kinematic capabilities and damping properties.

The main criterion for improvement was formulated as an expansion of the kinematic adaptability of the discs. Whereas in the initial configuration the discs move predominantly along the axis of the rod, the proposed approach provides for additional angular displacement relative to the vertical axis. This approach makes it possible to take into account the components of the tension force arising when the thread passes at an angle to the axis of the rod. Artificial intelligence tools were used as an auxiliary means in the preparation, systematization, and editorial processing of up to 10% of the research materials.

ANALYSIS AND RESULTS

The examined design of the needle thread tension regulator includes a rod rigidly fixed in the machine head, two convex tension discs, elastic elements, and an adjusting nut. The needle thread passes between the discs. When the adjusting nut is rotated, the degree of deformation of the rubber element changes and, accordingly, the clamping force exerted by the discs on the thread is adjusted.

In the first configuration considered (Fig. 1), two rubber bushings are used. According to the original description, the width and diameter of the first bushing are selected to be two times smaller than the corresponding dimensions of the second bushing. During tension adjustment, the main deformation occurs in the first bushing, while the second bushing undergoes less deformation. This configuration makes it possible to smooth abrupt changes in thread tension and reduce the likelihood of thread breakage.

In the second configuration (Fig. 2), three spherical rubber rings with different stiffness values are installed on both sides of the tension discs. Their stiffness relationship is defined as $C_1 > C_2 > C_3$. The more compliant elements provide the possibility of additional deformation, while the spherical contact geometry creates conditions for both axial and angular displacement of the discs.

A comparative description of the considered solutions is presented in Table 1.

Table 1. Comparative Characteristics of the Structural Configurations of the Needle Thread Tension Regulator

Indicator	Configuration with Rubber Bushings	Configuration with Spherical Rings	Direction of Improvement
Elastic element	Rubber bushings	Spherical rings of different stiffness	Adaptive elastic system
Main movement of the discs	Axial displacement	Axial displacement with the possibility of angular movement	Two degrees of mobility
Damping	Due to deformation of the bushings	Due to combined deformation of the rings	Expansion of the damping range
Response to changes in tension	Variation in the clamping force of the discs	More flexible deformation of the elastic rings	Consideration of both the magnitude and direction of the force

Source: developed by the authors based on calculation data.

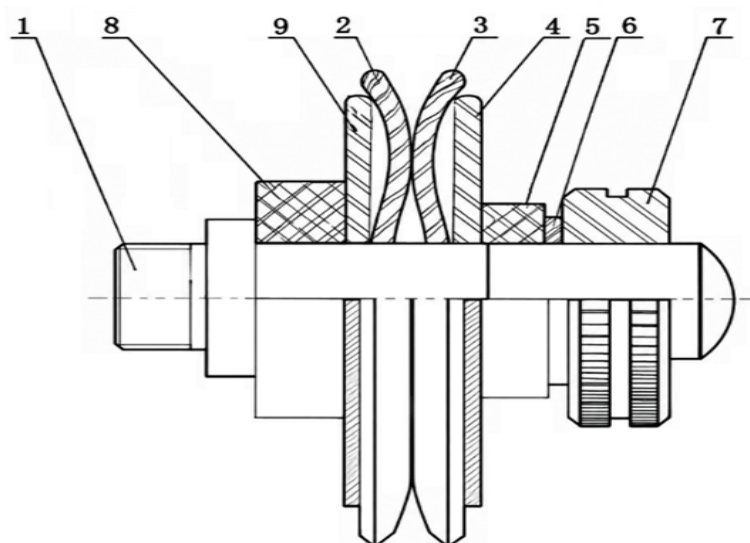


Fig. 1. Needle Thread Tension Regulator of a Sewing Machine

Source: developed by the authors based on calculation data.

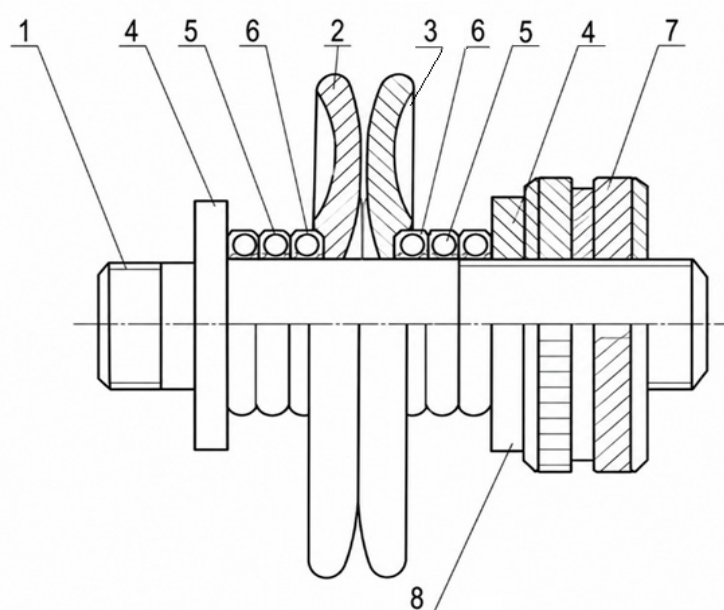


Fig. 2. Three-Ring Rubber (Double-Sided) Needle Thread Tensioner

Source: developed by the authors based on calculation data.

A comparison of the designs shows that both configurations are based on the controlled deformation of elastic elements. However, their kinematic capabilities differ. In the first configuration, the main change in the position of the discs is associated with axial displacement along the rod. In the second configuration, the spherical rings and the corresponding geometry of the contact surfaces create conditions for more complex movement of the discs.

It should be noted that the direction of the thread tension force is of particular importance. During operation, the thread approaches the regulator at a certain angle to the axis of the rod. Therefore, the tension force can be represented as a vector and decomposed into components relative to the rod axes. As a result, the disc is subjected not only to an axial force but also to a moment that promotes its angular displacement.

If the design permits only one principal movement—along the axis of the rod—a portion of the dynamic action cannot be compensated for kinematically. Introducing additional angular displacement allows the discs to adapt to changes in the direction of the load. As a result, conditions are created for a more uniform variation in thread tension at the inlet and outlet of the regulator.

Based on the analysis, the main direction for further improvement is to increase the number of degrees of mobility of the tension discs from one to two. At the same time, controlled angular displacement should be ensured, the possibility of regulating the average tension level should be preserved, and excessive reduction of the clamping force should be avoided.

The scientific novelty of the study lies in substantiating an approach to improving the needle thread tension regulator by increasing the number of degrees of mobility of the tension discs. In contrast to configurations dominated by axial displacement, the proposed approach takes into account an additional angular component of motion. This makes it possible to consider the elastic system of the regulator as a more adaptive mechanism for compensating for dynamic changes in load.

The practical significance of the proposed developments lies in the possibility of applying the formulated principle in the design of new thread tensioning devices. Subject to subsequent experimental verification, this approach can be used to select the stiffness of elastic elements, the geometry of contact surfaces, the range of angular displacement, and rational adjustment parameters.

CONCLUSION AND SUGGESTIONS

The analysis of needle thread tension regulator designs showed that the effectiveness of the device is determined not only by the possibility of regulating the thread clamping force but also by the ability of the elastic system to compensate for dynamic changes in load. The configurations considered, using rubber bushings and spherical rings, provide damping and tension adjustment through the deformation of elastic elements.

It was established that the main kinematic limitation is the predominantly uniaxial movement of the tension discs. Considering that the thread approaches the regulator at an angle to the axis of the rod, it is advisable to expand the kinematic capabilities of the discs by introducing additional angular displacement.

As the main direction for improvement, a structural configuration providing two degrees of mobility of the tension discs is proposed. At the same time, the elastic system should ensure controlled deformation, sufficient damping, and maintenance of the required tension level. For a final assessment of effectiveness, experimental studies should be conducted with measurement of thread tension dynamics at different sewing speeds and adjustment modes.

At the next stage, it is proposed to develop a prototype regulator, determine rational parameters of the elastic elements, and conduct comparative tests against the basic design. The results of these tests will make it possible to quantitatively evaluate the effect of the additional degree of mobility on tension uniformity, thread breakage, and stitch formation quality.

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